midday in the summer equinox, and thus found 7° 12″. It is added that at Syené the bottom of the wells was fully lighted by the sun on that day, so that Eratosthenes concluded zero for the zenith distance of that body. I believe rather that the Greek astronomer caused an observation to be made at Syené with a gnomon, an instrument then very common in Egypt, and that that distance resulted from an effective observation, as well as in the case of Alexandria. We shall see that this conjecture is perfectly justified. We know that the observations made on the dark shadow of a gnomon bear a constant error equal to the semi-diameter of the sun, or, to speak more accurately, that they give the zenith distance of the upper edge of that body. The ancients do not seem to have remarked this; and in fact, as they deduced from their observations only the obliquity of the ecliptic or the epoch of the solstice, it did not concern them, for by combining the observations of the summer with that of the winter solstice, the error in question disappeared from the difference. But it is exactly the same here, since we have not to do with absolute latitude, but with the difference of latitude of two places at which the centre of the sun is found at midday on the same side of the vertical. Thus the amplitude 7° 12′ concluded by Eratosthenes is correct; it has moreover the advantage of not being sensiby affected by refraction.

Here is a first verification. On opening the *Connaissance des Temps* we find—

	°	′
For the latitude of Alexandria	31	12
,, ,, Syené	24	5
Difference	7	7

instead of 7° 12′. The difference, whatever may be the cause, is very small.

Here is a second and more delicate verification. The latitude of the point in Alexandria, where Eratosthenes observed, could not differ much from that which we have given. By adopting that and 7° 12′ for the zenith distance of the upper edge of the sun at the winter solstice we find $31° 12' - (7° 12' + 16') = 23° 44'$ for the obliquity of the ecliptic. Syené gives $24° 5' - 16' = 23° 49'$. Is it possible that in the year 250 B.C. the obliquity of the ecliptic was from 23° 44′ to 23° 49′? From 1750 A.D. to 250 B.C. is 2000 years. At the rate of 48″ diminution per century the obliquity would be

$$23° 28' 18'' + 48'' \times 20 = 23° 44'.$$

The observation of Eratosthenes at Alexandria is then authentic, and moreover very precise. That of Syené presents an error of only 5′.

There remains the geodetic operation. Egypt was the only country of antiquity which rejoiced in a survey. The valley of the Nile was very populous at that epoch, as far as Syené, and no doubt the survey extended thus far. Eratosthenes must have had every facility for procuring the necessary documents. He must have taken into account the difference of longitude of 2° 59′ which exists between the two cities, without having had to determine it directly. I regard, then, the distance of 5000 stadia, in round numbers, as being quite as accurate as the other parts of his operation, and as applying to the arc of meridian comprised between the parallels of the two cities.

We finally conclude from this 694·4 stadia for the degree. The Greek astronomer gave, in round numbers, 700 stadia. What was this stadium?

To reply to this question I calculate the arc of meridian from Alexandria to the parallel of Syené, with the actual element of the terrestrial ellipsoid. It is 797,760 metres. At the rate of 5000 stadia we find 159·55 metres for the stadium. At the rate of 600 feet for the stadium, the foot adopted by Eratosthenes would be 0·266 metres. This was then the ancient Egyptian foot, which we now reckon at 0·27 metre; and in fact it was with this foot that the survey of Egypt must have been made. By this reckoning the 5000 stadia give—

$$5000 \times 600 \times 0{\cdot}27 = 810{,}000 \text{ metres},$$

showing a difference of 12,240 metres, partly owing to that of the points of departure, partly to the error which we perhaps make in the length of the Egyptian foot in carrying it to 0·27 metre. Thus the measurement made in Egypt, more than 2100 years ago, by an able Greek astronomer, is as good as authentic. All the existing causes of uncertainty do not alter it more than one-sixth. It is certainly not from this quarter that the error can come for which we seek.

Nor is it in the measurement of Ptolemy, for he tells us he went through the same operations and found the same results; only he gives 500 stadia to the degree instead of 700. This difference is evidently due to the fact that Ptolemy, who lived 400 years after Eratosthenes, under another domination, did not make use of the same foot. In fact he employed the stadium of 600 Phileterian feet, and as this foot is about 0·36 metre, while the ancient Egyptian foot was only 0·27 metre, he had to reduce the 700 stadia of his predecessor to $700 \times \frac{27}{36} = 525$, or 500 in round numbers.

These estimates are confirmed, finally, by the Arabian astronomers, who measured, in 827 A.D., an arc of 1° in the plains of Mesopotamia. They found fifty-six miles, and concluded that they had thus verified the number of Ptolemy. The Arab mile being 2100 metres, the arc measured is found to be 117,600 metres, which corresponds to a stadium of 235 metres. This is very nearly the Phileterian stadium of 216 metres, except the error of the measurements seven times more sensible on so small an axis, and the uncertainty of our existing estimate of the Arabian mile in the time of the Kalif Almamoun.

To resume: the estimate of Ptolemy is only a sort of conversion of the excellent measurement of Eratosthenes in units of another epoch and of different length. It would thus lose a little of its first precision; but, such as we find it in Ptolemy, the English geographers were fully justified in taking it for the basis of a valuation of the arc of 1′ and of offering it to the navigators of their country. Only, and it is here the mistake lies, they believed that the great Greek astronomer of Alexandria must have made use of the Greek foot. This is one and a half hundredths larger than the English foot. If the English geographers of the sixteenth century had strained this valuation ever so little, and had carried it to $\frac{5}{100}$ths, they would have found 630 English feet for the stadium, which they believed to be 600 Greek feet, and these 630 feet or 210 yards, multiplied by 500, would give them 105,000 yards for the degree, and exactly 1760 yards for the mile. The English mile, then, has evidently been deduced from the measure of Ptolemy; its error of one-sixth is solely due to the fact that the Greek foot has been confounded with the Phileterian foot.

LAURENTIAN GNEISS OF IRELAND

IN 1863 Dr. T. Sterry Hunt pointed out the resemblance of some specimens of rocks and minerals from Donegal which he had examined to those of the Laurentian series of North America. These rocks and minerals have been described by Dr. Haughton and Mr. R. H. Scott, who have pointed out that the "typical Donegal granite" is really a metamorphic bedded rock, containing in some places bands of crystalline limestone or marble. Outside the granite district are the newer series of schists, quartzites, and limestones, which occupy the whole of the Promontory of Innishowen, and were identified by the late Prof. Harkness with the Lower Silurian metamorphic series of the Highlands of Scotland. These two groups are shown on Griffith's Geological Map of Ireland, and it

will be seen on an inspection of this map that the quartzite series is represented as terminating obliquely against the margin of the granite or gneiss. This obliquity has never (as far as I can discover) been explained. The prevalent opinion seems to have been that the newer series has been converted into the older by increased metamorphic action. For some time past I never studied Griffith's map without the impression that the obliquity was due to unconformity of stratification, and on the determination of this point plainly rested the question whether the granitoid gneiss was, or was not, of Laurentian (or "Archæan") age.

Having had the advantage of a visit to some of the sections in the North Highlands of Scotland, in company with my colleague, Mr. R. G. Symes, under the able guidance of Prof. Geikie, last summer, I was in a position much more favourable for undertaking the investigation of this interesting question than would otherwise have been the case; and in the recent visit to Donegal I was accompanied by Mr. Symes and Mr. Wilkinson, of the Irish Survey, who rendered material aid in this preliminary survey.

The knowledge thus obtained has been of essential service, and I am happy to be able to state that we have succeeded in identifying the Donegal gneissic series, both as regards its mineral characters and its unconformable relations to the Lower Silurian series with the Laurentian beds of Sutherland and Ross. The relations of the two series in Donegal are similar to those which are to be observed in the Laxford and Rhiconich districts, where the Cambrian sandstones and conglomerates are absent, and where, in consequence, the Lower Silurian quartzites and limestones rest directly on the old gneiss. These conditions can be clearly made out in the neighbourhood of Lough Salt, near Glen, where successive beds of quartzite, limestone, diorite, and schist of the Lower Silurian series terminate abruptly at the margin of the gneissic series. We satisfied ourselves that this truncation of the Silurian beds is not due to faulting, as there is no appearance of disturbance or fracturing amongst the strata on either side. Similar—though less clear—indications were observable all along the eastern or southern margin of the gneissose district. Nor was the unconformity confined to the Silurian series, as we found that the beds of this formation came into contact with those of different geological horizons amongst the gneissic series at different places; there occurs, in fact, a double unconformity.

When examining the gneissic series we were often struck by the resemblance presented by the beds to those of Sutherlandshire, particularly amongst the lower portions. The massive foliated rock formed of red orthoclase, greyish oligoclase, green and black mica, and quartz, traversed by pegmatite veins, is identical in character with that from Rhiconich and Laxford; while the upper beds are interstratified with hornblendic and micaceous schists like those near Scourie. The occurrence of thin beds of white and grey marble, with sphene, idocrase, &c., in the Laurentian gneiss, seems peculiar to the Irish rocks, and brings them into close relationship with those of Canada.

A new basis has thus been formed for the whole superstructure of the Irish geological formations as deeply seated as that of any other country, and there can be little doubt that as the Laurentian beds have thus been recognised on the clearest evidence in Donegal, they may be recognised also in parts of Sligo, Mayo, and Galway, where the evidence is not so clear.

As I hope to have an opportunity of more fully stating the case at the forthcoming meeting of the British Association at York, it will be unnecessary here to enter on further details. I will only add that in speaking of the gneissic series as "Laurentian" I only wish it to be understood that the beds are contemporaneous with those underlying the Cambrian and Lower Silurian series of the Scottish Highlands. Whether they are really the representatives in time of the Laurentian beds of Canada is immaterial for my present purpose. For my own part I consider the preponderance of the evidence to be in favour of the view that they are in the main representative.

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JOSEPH BARNARD DAVIS

AFTER a short illness Dr. J. Barnard Davis died last week at his residence at Hanley, Staffordshire, being about eighty years of age. In the summer of 1820, while still a student, he made a voyage to the Arctic regions in the capacity of surgeon to a whaling ship. In 1823 he became a licentiate of the Society of Apothecaries; twenty years later he passed the College of Surgeons, and in 1862 took the M.D. degree of the University of St. Andrew's. In 1868 he was elected into the Royal Society. Soon after obtaining his first qualification he settled down in the Potteries, and but for what he describes, in the preface to his "Thesaurus Craniorum," as "an accidental conversation with a friend," might have remained through life leading the useful but uneventful life of thousands of general practitioners in the country, unknown beyond his immediate sphere of work. That accidental conversation however lighted up some smouldering embers of an interest which long before had been kindled by the lectures of Lawrence on the Natural History of Man, and led to the researches which resulted in the publication (in conjunction with the late Dr. Thurnam) of the "Crania Britannica," or delineations and descriptions of the skulls of the aboriginal and early inhabitants of the British Islands, illustrated with sixty-seven beautifully-executed lithographic plates, completed in 1856. Besides this Dr. Davis published many memoirs on anthropological subjects, including one "On Synostotic Crania among Aboriginal Races of Man," one on "The Osteology of the Tasmanians," one on "The Peculiar Crania of the Inhabitants of Certain Groups of Islands in the Western Pacific," and one published in the *Philosophical Transactions* for 1868, "On the Weight of the Brain in different Races of Man."

But it was by his famous collection, rather than by his writings, that Dr. Barnard Davis was best known, and the time, labour, and money which he spent in gathering it together is his greatest service to science. During a long period of time, in which the national and other public collections were losing the golden opportunities afforded by the extension of English adventure and commerce to all parts of the world, and allowing races to die out or their characteristics to become obliterated by intermixture with others, Dr. Davis let no chance of procuring specimens pass by, and was unwearied in his correspondence with travellers, collectors, and residents in foreign lands. He thus amassed together within a few rooms of a small house in Staffordshire a collection of crania and skeletons, nearly all with carefully-recorded histories, far exceeding in size that in all the public museums of the country put together, and only surpassed in very recent years by any of the Continental collections. In 1867 he published a catalogue called "Thesaurus Craniorum," which not only contains a description and many figures of the specimens, with 25,000 measurements, but which is also a perfect storehouse of information, owing to the literary references with which it abounds. The publication of this catalogue made the collection so well known that it naturally led to its increase, and in 1875 it became necessary to publish a supplement on the same plan, in which the history of the literature of the subject was continued to date. The catalogue and supplement contain descriptions of more than 1700 specimens, mostly crania.

Warned by failing health and increasing years of the